MASTER OF SCIENCE
IN
ELECTRICAL ENGINEERING

ANALYSIS OF MECHANISMS FOR TCBE CONTROL OF OBJECT REUSE IN CLIENTS

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This study contributes to the realization of a high assurance Multilevel Secure Local Area Network. They system consists of a Trusted Computing Base (TCB) that acts as a server base. Clients are Commercial-off-the-Shelf (COTS) workstations and software, augmented with a hardware-based TCB Extension (TCBE). This work concentrates on object reuse control on the client, which is one of the security services to be provided by the TCBE.

Object reuse mechanisms are designed to assure that sensitive information does not persist across sessions of session level changes. Twenty-nine chips on the PC motherboard were analyzed. Possible solutions were proposed and evaluated for object reuse control of four storage areas: main memory, AGP memory, cache and Real Time Clock (RTC) memory. The feasibility of one proposed solution was demonstrated.

It was found that main memory can be cleared by slowing its refresh rate. It was determined that AGP memory cannot be read out by devices on the PCI and ISA bus. The Intel INVD command can be used to clear cache. RTC memory can be accessed and its integrity checked by TCBE software.

This study establishes a foundation for object reuse control efforts targeting COTS PC products manufactured by various vendors.

DOD KEY TECHNOLOGY AREAS: Computing and Software, Electronics, Other (Information Security)

KEYWORDS: Multi-level Secure Local Area Network (MLS-LAN), Trusted Computing Base (TCB), TCB Extension (TCBE), Object Reuse, Secure Systems, Object, Subject, Computers, Networking, Information Security

AN ULTRA WIDEBAND ANTENNA WITH SIZE CONSTRAINTS

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Aircraft antennas for the low VHF frequency range are large and adversely affect aircraft aerodynamics. In order to reduce antenna size dielectric or ferrite cladding may be considered. Recent work on the properties of dielectric loaded antennas has suggested that some improvement in performance or reduction in size of an antenna can be achieved by coating it with a high-permittivity dielectric material. The objective here is to design a high power, ultra-wideband aircraft antenna operating in the frequency range from 30 MHz to 500 MHz with vertical polarization and omni-directional azimuth radiation pattern by employing dielectric

cladding of metal antennas. An additional constraint is that the antenna's aerodynamic drag should be as low as possible. A number of antennas were successfully designed and simulated. The computer-predicted performance of these new designs surpasses the performance of the current antenna. The three best designs (occupying a larger volume than the current antenna) have VSWR less than 3 (relative to 50 ohms) from about 50 MHz to more than 500 MHz with the average VSWR of less than 1.5. In comparison, the current antenna can operate from about 140 MHz to 500 MHz with the VSWR<3 and the average VSWR of about 1.9.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Sensors, Modeling and Simulation

KEYWORDS: Antennas, High Frequency Structure Simulator (HFSS)

PROBABILITY OF SYMBOL ERROR FOR COHERENT AND NON-COHERENT DETECTION OF M-ARY FREQUENCY-SHIFT KEYED (MFSK) SIGNALS AFFECTED BY CO-CHANNEL INTERFERENCE AND ADDITIVE WHITE GAUSSIAN NOISE (AWGN) IN A FADING CHANNEL

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The probability of symbol error for coherent and non-coherent detection of M-ary frequency-shift keyed (MFSK) signals affected by other interfering MFSK signals (co-channel interference) and additive white Gaussian noise (AWGN) in a fading channel (Rayleigh and Rician models) is quantified in this thesis. First, theoretical expressions are derived for the symbol error probability as a function of the signal-to-noise ratio SNR and the signal-to-interference/jamming ratio SJR. Next, using SIMULINK and the MATLAB/SIMULINK Communications Toolbox, we develop models to determine the symbol error probability for Monte Carlo type simulations. Finally, we compare the theoretical symbol error probabilities with the simulation's results and identify the differences and their possible causes.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Electronics Warfare, Modeling and Simulation

KEYWORDS: Communications, MFSK Coherent - Non-coherent Detection, Interference, AWGN, Fading Channel, Simulink

TESTING AND EVALUATION OF THE SMALL AUTONOMOUS UNDERWATER VEHICLE (AUV) NAVIGATION SYSTEM (SANS)

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At the Naval Postgraduate School (NPS), a small AUV navigation system (SANS) was developed for research in support of shallow-water mine countermeasures and coastal environmental monitoring. The objective of this thesis is to test and evaluate the SANS performance after tuning the filter gains through a series of testing procedures.

The new version of SANS (SANS III) used new hardware components which were smaller, cheaper, and more reliable. A PC/104 computer provided more computing power and, increased the reliability and compatibility of the system.

Implementing an asynchronous Kalman filter in the position and velocity estimation part of the navigation subsystem improved the navigation accuracy significantly. To determine and evaluate the overall system performance, ground vehicle testing was conducted. Test results showed that the SANS III

was able to navigate within ±15 feet of global positioning track with no global positioning update for three minutes.

DoD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: INS, GPS, AUV, SANS, Navigation, Kalman Filter

PERFORMANCE ANALYSIS OF THE HIGHER ORDER CYCLOSTATIONARY BASED CLASSIFIER

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Testing of the Higher Order Cyclostationary Based Classifier (HBC) is conducted to evaluate system operational performance. Utilizing Higher Order Cyclostationary (HOCS) analysis techniques the HBC is designed to automatically detect and classify communications and radar signals contained in input signal samples. While test results utilizing earlier data show a very effective system, a more rigorous test utilizing Agilent Inc.'s Advanced Design System (ADS) is herein carried out. Numerous modulation type samples were input with a variety of signal generation parameters. The results of the HBC analysis reveal a system which experiences difficulty in performing modulation detection and classification of the input data at moderate to high signal to noise ratios. Substantial improvement to the algorithm and interface appears to be required before operational implementation of this system is practical.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Cyclostationary, Cyclostationarity, Digital Signals, Signal Classification, Signals Intelligence (SIGINT)

VULNERABILITIES IN THE OPEN SHORTEST PATH FIRST ROUTING PROTOCOL

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In order to reduce the number of successful attacks against the U.S. Government's computer networks, resources must be invested not only in to implementing known fixes and security measures but also in to the identification and correction of vulnerabilities before adversaries can exploit them. This thesis identifies one such vulnerability in the Open Shortest Path First (OSPF) Interior Gateway Protocol. This protocol is responsible for deciding which route network traffic will take, assuming multiple routes exist, in an autonomous system. This vulnerability manipulates routers running OSPF into altering the route that certain traffic takes without introducing abnormalities that would alert system administrators. In addition, this manipulation can be reversed without alerting administrators or extended indefinitely.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Internetworking)

KEYWORDS: Open Shortest Path First, OSPF, Vulnerabilities, Exploits, Routing Protocol, Interior Routing Protocol, Interior Gateway Protocol

TRANSIENT RESPONSE TO SINGLE EVENT UPSET IN SILICON-ON-INSULATOR FIELD EFFECT TRANSISTORS

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Silicon-on-Insulator (SOI) technology provides promising radiation hardening characteristics but the effect of microdose issues are not understood. As transistors shrink, trapping of small amounts of charge in a gate oxide can cause threshold voltage shifts in Metal Oxide Semiconductor Field Effect Transistors (MOSFETs). This thesis examines the effects of enacting a microdose single event effect (SEE) upon a thick gate oxide of an SOI MOS capacitor in order to determine the degree of damage to the device and the recombination yield curve. Based on simulation data from the Silvaco software suite, a recombination yield curve is explored which can provide simulation data that can be used to design future SOI devices for DOD. Simulation results are compared to previously published, Single Event Upset (SEU) test data provided by the U.S. Army's Harry Diamond Laboratories to verify validity.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Electronics, SOI, Radiation Hardened

ELECTRIC PROPULSION FOR MILITARY GEOSYNCHRONOUS SATELLITES

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Revolutionary changes in the launch, delivery, and operation of satellites over the next decade will directly impact life-cycle costs by providing a capability to place larger payload mass in space at less cost. The cost reducing delivery systems under development for large LEO constellations can be combined with electric propulsion (EP) upper stages to offer dramatic reduction in payload cost per kilogram for MEO and GEO applications. Higher energy-density solar arrays coupled to electric *primary* propulsion systems will offer significantly increased payload mass fractions on orbit, greater flexibility in relocating satellites, longer satellite lifetimes, and less penalty for de-orbiting expired satellites. By coupling low-thrust propagation algorithms with comparative mass-fraction equations, this thesis provides a systematic design approach for meeting on-orbit payload and power requirements. Stationkeeping, orbit insertion, GEO rephasing and deorbiting requirements are addressed. Two types of EP thrusters are investigated: electron bombardment ion thrusters and Hall-Effect thrusters. Electric propulsion parameters are derived and integrated into mission-specific mass fraction equations. This allows for determination of the optimal thruster type and operating point for each mission. Total mass savings using EP is ultimately translated to a required LEO insertion mass for a given payload and transfer time.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Space Vehicles

KEYWORDS: Electric Propulsion, Ion Thrusters, Hall-effect Thrusters, Orbit Transfer, Satellite Propulsion, Low-thrust Satellite Maneuvers, Stationkeeping, Geosynchronous Rephasing

SIMULATION OF SIGNALING SYSTEM NO.7 MESSAGE TRANSFER PART 2

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The objective of this work is to perform simulation modeling of the Signaling System No.7 (SS7) network with particular emphasis on modeling of the Message Transfer Part (MTP) Level 2. The basics of common channel signaling using Signaling System No. 7 is initially outlined and discussed with reference to the ITU-T Q.7xx-Series Recommendations. This includes the protocol stack, signaling points, signaling links and typical network structure. In particular, the functionality of the Message Transfer Part, which provides the main mechanism to convey signaling messages, is discussed in detail.

Subsequently the modeling of the Message Transfer Part, in particular MTP level 2, using the simulation tool OPNET from MIL3. Inc. is presented. The model uses a multi-layer modular approach, with each layer corresponding to the SS7 layer it is modeling. The functional blocks within each layer are thought of as processes. With their buffers and processors, these processes form a complex interlinked queuing model that is complicated to analyze but is readily simulated.

In order to illustrate the use of the simulation model, the basic linkset delay between two signaling points under a heavy traffic load is simulated and compared with analysis based on M/G/1 queuing models.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Signaling System No. 7, Link Delay

INVESTIGATION AND APPLICATION OF RECENT WEB-BASED TECHNOLOGIES TO THE TEACHING OF ELECTRICAL ENGINEERING COURSES

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This thesis is part of an effort by the Department of Electrical and Computer (ECE) Engineering to implement distributed learning to better serve its students. Distributed learning is especially useful for a modern technologically-oriented military, which is geographically distributed. The goal of this thesis is to develop a prototype web-based course, specifically, EC2820 - Digital Logic Design. A primary sub-goal is to quantify time required and to understand the tradeoffs involved. A secondary sub-goal is to evaluate web page tools.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Web-Based Learning, Multimedia, On-Line Course

TESTING AND EVALUATION OF SHIPBOARD WIRELESS NETWORK COMPONENTS

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Fundamental challenges facing program managers and information technology decision makers today are the identification of architectures and technologies that reduce the cost of maintaining computer networks while simultaneously increasing worker productivity. Advances in wireless communications and

subsequently, wireless local area networks (WLANs) permit mobile users to share information without being hardwired to a network. These mobile devices will enable shipboard personnel to submit damage control reports, update equipment logs, view technical manuals and order repair parts, without being confined by the limitations of a wired network. The advantages of WLANs are virtually endless, ranging from the uses previously discussed, to communications between the ship and its small boats, to automated data transfer of degaussing results, and even direct parts ordering from a pier-side supply center.

This thesis provides a hardware analysis and discusses coverage limitations of commercially available WLAN components for use onboard naval vessels. Utilization of this mobile equipment will improve DC communications and watchstander productivity. With remote access to the wired network backbone, personnel can conduct transactions instantaneously whenever and wherever the need arises. A discussion of the theories and principles governing the operation of WLANs is presented, followed by a laboratory evaluation of current, commercially available components.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications, Other (Wireless Communications)

KEYWORDS: Wireless Local Area Networks

STEPPED FREQUENCY IMAGING RADAR SIMULATION

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In this thesis, a technique involving Stepped Frequency and Inverse Synthetic Aperture Radar (ISAR) processing have been employed to develop two-dimensional radar images, for example, for an aircraft target. Radar returns from prominent scatterers of various parts of the target will be processed and displayed. The processing is a combination of two high-resolution processes: development of a high-range resolution (HRR) profile in slant range using the stepped frequency waveform, and the development of a high-resolution profile in cross-range using the ISAR technique. With these two techniques complementing each other, images of targets' dominant scatterers can be extracted, processed and displayed. With intelligence databases built over time, precise recognition of target type can be identified.

DoD KEY TECHNOLOGY AREA: Other (Radar Imaging Techniques)

KEYWORDS: Imaging, Radar, Stepped Frequency, Inverse Synthetic Aperture, Fast Fourier Transform

OPNET SIMULATION OF SIGNALING SYSTEM NO.7 (SS7) NETWORK INTERFACES

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This thesis presents an OPNET model and simulation of the Signaling System No.7 (SS7) network, which is dubbed the world's largest data communications network. The main focus of the study is to model one of its levels, the Message Transfer Part Level 3, in accordance with the ITU-T Recommendation Q.704. An overview of SS7 that includes the evolution and basics of SS7 architecture is provided to familiarize the reader with the topic. This includes the protocol stack, signaling points, signaling links and a typical SS7 network structure. This is followed by a more detailed discussion about the functions of the various parts of the protocol, in particular, the functionality of the Message Transfer Parts. The OPNET modeling of the Message Transfer Part level 3, in particular the signaling message handling aspect, is presented. The simulation model presented uses a hierarchical approach, with each level corresponding to the SS7 level it

is modeling. Simulation results of different scenarios using varying parameters, such as packet transmission time, packet length, and load sharing, for a typical SS7 network are also presented.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Signaling, Signaling System No.7 Kernel, Message Transfer Part, OPNET, Message Signaling Units

SIGNAL CLASSIFICATION USING THE MEAN SEPARATOR NEURAL NETWORK

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The explosion of digital technology provides the warrior with the potential to exploit the battlespace in ways previously unknown. Unfortunately, this godsend is a two-edge sword. Although it promises the military commander greater situational awareness, the resulting tidal wave of data impairs his decision-making capacity. More data is not needed; enhanced information and knowledge are essential.

This study built upon the Mean Separator Neural Network (MSNN) signal classification tool originally proposed by Duzenli (1998) and modified it for increased robustness. MSNN variants were developed and investigated. One modification involved input data preconditioning prior to neural network processing. A second modification incorporated projection space variance in a re-defined performance parameter and in a newly defined training termination criterion. These alternative MSNN architectures were measured against the standard MSNN, a single-layer perceptron, and a statistical classifier using data of varying input dimensionality and noise power. Classification simulations performed using these techniques measured the accuracy in categorizing data objects composed of artificial features and features extracted from synthetic communication signals. The projection space modification variant exceeded all classifiers under noise-free conditions and performed comparably to the standard MSNN in noisy environments. The preconditioned input method produced a poorer response under most situations.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Electronics, Electronic Warfare

KEYWORDS: Signal Classification, Neural Networks, Mean Separator Neural Network, Single Layer Perceptron, Statistical (Quadratic) Classifier

DETECTION OF SHORT TRANSIENTS IN COLORED NOISE BY MULTI-RESOLUTION ANALYSIS

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Detecting short transients is a signal processing application that has a wide range of military uses. To be specific in Undersea Warfare, sensitive signal detection schemes can increase the effective range of active and passive sonar operations. Current research is being done to improve the capability of detecting short signals buried within background noise, particularly in Littoral waters. Starting with a colored noise model, this thesis will introduce two denoising methods based on multi-resolution analysis and compare the results to current transient detection techniques. The goal of this thesis is not necessarily to replace current detection schemes, but rather to enhance them and thereby making the procedure more robust.

DoD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Wavelets, Filter Banks, Multi-resolution Analysis, Transient Signals

MISSILE TERMINAL GUIDANCE AND CONTROL AGAINST EVASIVE TARGETS

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The ability of a missile to intercept a target in its flight is greatly determined by the guidance law employed in the guidance processing of the missile. Two main types of guidance laws are employed in the majority of missiles, namely proportional navigation (PN) and command to line-of-sight (CLOS). The effectiveness of CLOS however is limited to shorter ranges of up to about 6km, due to its sensitivity to angular tracking errors between the ground station and the target. PN is probably the most widely used homing guidance law, which seeks to null the line-of-sight (LOS) angle rate by making the missile turn rate be directly proportional to the LOS rate. PN does not suffer from the range limitation encountered by CLOS because it is self-homing and relies on an onboard seeker that provides target's LOS information directly. We modeled the two-dimensioned missile-target intercept geometry with CLOS and PN guidance laws using Matlab® Simulink®. The engagement results for a non-maneuvering target were first established as a benchmark and subsequently compared for the case of a target with a 9-g evasive maneuver. While conventional PN was shown to be effective against a non-maneuvering target, it has to be modified to improve its performance against a maneuvering target. Simulations for a proportional navigation strategy incorporating bang-bang control was carried out and analyzed. The performance of this strategy is also presented.

DoD KEY TECHNOLOGY AREA: Other (Missile Guidance Laws)

KEYWORDS: Missile Guidance Laws, Proportional Navigation, Command to Line-of-Sight

DESIGN OF AN ULTRA-WIDEBAND LOW PROFILE VERTICALLY POLARIZED UHF ANTENNA FOR THE U.S. GROUND TROOP HELMET

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The Joint Tactical Radio System (JTRS), which will operate from 2-2000 MHz, will meet emerging needs for ultra-wideband radios for the tactical battle space. Conventional antennas for tactical radios are capable of operating in a narrow band of frequencies. In addition, they have large visual profiles that expose the radioman's position. The COMbat Wear INtegration (COMWIN) antenna system developed at NPS incorporates wideband antennas into the soldier's combat wear to meet the above-mentioned challenges. In this thesis, a helmet-mounted antenna was designed to operate from 500-2000 MHz. Its performance was predicted through simulation. A prototype was built and its performance measured. The antenna is conformal to the shape of the soldier's helmet. It uses copper polyester to provide an antenna that is easily incorporated into the helmet. Measurements on the prototype showed good fit with theoretical predictions. The antenna's VSWR was less than 3:1 between 500 and 2000 MHz, except for an isolated band around 900 MHz. The presence of an operator wearing the helmet improved the VSWR. Simulation results at 500 MHz, 1000 MHz and 2000 MHz showed that the radiation patterns were omnidirectional and concentrated in the sector from the horizon to 60° elevation.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Ultra-Wideband UHF Helmet Antenna, Conformal Antenna, VSWR, Lightweight, Low Profile, Vertically Polarized, Omnidirectional, Prototype Antenna

ANALYSIS FOR A TRUSTED COMPUTING BASE EXTENSION PROTOTYPE BOARD

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Agencies, institutions, individuals are demanding the use of commercial-off-the-shelf (COTS) systems and cannot enforce mandatory security policies with these systems, which are equipped only with discretionary access controls. An inexpensive implementation of a multi-level secure local area network utilizing commercial-off-the-shelf hardware and software does not exist.

The Naval Postgraduate School (NPS) is developing a Multi-level Secure Local Area Network (MLS LAN) to provide secure information sharing, classified at different security levels. The MLS LAN extends the high assurance of an evaluated multi-level secure system to a LAN that is formed by commercial personal computers (PCs) running commercial operating systems and office productivity software. The MLS LAN accomplishes the defined functionality by using custom boards which are designed to be plugged into personal computers. The boards are named the Trusted Computing Base Extension (TCBE). The TCBE is intended to provide trusted path and object reuse supporting services to the network TCB.

This thesis describes the hardware and software components, structures, interfaces required for the TCBE to complete a trusted path and control the client PC. Potential implementations are suggested and analyzed for security implications. A preliminary TCBE prototype has been constructed and tested for selected TCBE functions. It is shown that the TCBE prototype can be made both non-by-passable and tamper resistant.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics

KEYWORDS: Multi-level Security, Trusted Path, High-Assurance, Network Client